

ELECTROACTIVE POLYMERS AS ARTIFICIAL MUSCLES - CAPABILITIES, POTENTIALS AND CHALLENGES

Yoseph Bar-Cohen

JPL/Caltech, (MC 82-105), 4800 Oak Grove Drive, Pasadena, CA 91109-8099

Phone 818-354-2610, Fax 818-393-4057, yosi@jpl.nasa.gov web: <http://ndea.jpl.nasa.gov>

Actuators are responsibility for manipulation and drive functions of active mechanisms and systems, such as robotics and locomotives. For many years, electromagnetic motors, electroactive ceramics (EAC), shape memory alloys (SMA) and others have been the leading choices of actuation mechanisms. Low-mass, compact, low power, and fracture tolerance are highly desirable characteristics of actuators, which are inherent to the emerging electroactive polymers (EAP). Even though such materials were known to exist in prior decades, materials with significant displacement levels were mostly reported in the last few years. EAP are low-density materials with large strain capability that can be as high as two orders of magnitude greater than the striction-limited, rigid and fragile EAC materials. However, these materials reach their elastic limit at low stress levels, with actuation stress that falls far shorter than EAC and SMA actuators.

The most attractive feature of EAP is their ability to emulate biological muscles with high toughness, large actuation strain and inherent vibration damping. This similarity gained them the name "Artificial Muscles" and offers the potential of developing biologically inspired robots. Such biomimetic robots can be made highly maneuverable, noiseless, agile, with various shapes including insect-like. Effective EAP offers the potential of making science fiction ideas faster reality that feasible with any other conventional w actuation mechanisms. Unfortunately, the force actuation and mechanical energy density of EAPs are relatively low limiting the potential applications that can be considered at the present time. To overcome this limitation there is a need for development in numerous areas from computational chemistry, comprehensive material science, electro-mechanic analysis and improved material processing techniques. Efforts are needed to gain better understanding of the parameters that control the electro-mechanical interaction. The processes of synthesizing, fabricating, electroding, shaping and handling will need to be refined to maximize their actuation capability and robustness. Under a JPL led NASA task, longitudinal and bending EAP are being investigated for planetary applications and devices, where dust wiper, gripper and robotic arm have been demonstrated. The dust-wiper is currently being developed for the Nanorover's optical/IR window, which is part of the MUSES-CN mission.

In 1999, for the first time the science and engineering community has been offered conferences (SPIE and MRS) that are solely dedicated to the subject of EAP. Also, government resources started to be devoted at unprecedented levels to sponsoring research in this area. The increased research and the improved collaboration among the developers, users and sponsors is expected to lead to progress at significantly accelerated rate. The author challenged the EAP community to develop robotic arms actuated by artificial muscles that would win an arm wrestling match with human. If such a challenge becomes successful it would be possible to help physically impaired individuals perform function that hopefully can rich the level jogging.